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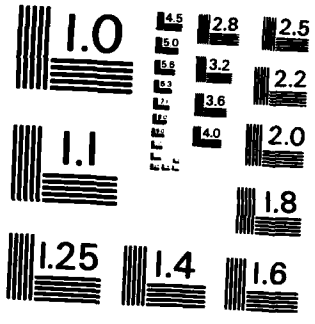

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FOREIGN TECHNOLOGY DIVISION

OCCURRENCE OF FOEHNS IN THE WEST BIESZCZADY MOUNTAINS

by

Adam Malicki and Edward Michna

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By: Adam Malicki and Edward Michna

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OCCURRENCE OF FOEHNS IN THE WEST BIESZCZADY MOUNTAINS

Adam Malicki and Edward Michna

Department of Physical Geography, UMCS, Department of Meteorology and Climatology, UMCS, and Scientific Station in Rownia, district Ustrzyki Dolne

Submitted 1 August 1968

Introductory published literature about the occurrence of foehns in our Carpathian Mountains has not been available until now. At the same time, the population in the Sanok Dales and the Carpathian Plateau, extending to the north from the depressions corresponding to the central syncline are well known by their strong, often persistent winds, referred to by the local inhabitants as "Dukla winds", increasing in intensity, especially during the early spring.

Typical manifestations of foehns were observed already during the first months of observations made at the Scientific Station of the Department of Physical Geography, Marie Curie-Sklodowska University in Rownia, district Ustrzyki Dolne. From the experience of persons who have stayed at the station in Rownia, it is known that a forecast of an approaching foehn is usually announced by the appearance of classical altocumulus lenticularis cloud formations, followed by a relatively sudden drop in pressure, temperature rise, and drop in relative air humidity. At the same time, after a prevailing calm in the atmosphere, the intensity of the wind increased, the wind gusts exceeded the 20 m/s scale, and sometimes the wind persisted for several days in a row.

In this article we would like to present only preliminary results of observations of these winds, which occur in the western Bieszczady Mountain region and postpone a more thorough characterization until a later date, on which a more complete observation period spanning 10 years will be available. This preliminary study is based on the results of measurements made in the 1961-1966 period at six stations of the State Institute of Hydrology and Meteorology, specifically the stations: Baligrod, Brzegi Dolne, Komancza, Lesko, Sanok, and Ustrzyki Gorne, and in addition on more precise measurements and observations made at the Scientific Station of the Department of Physical Geography of the UCMS [Marie Curie-Sklodowska University] in Rownia.

Daily synoptic maps beginning at 00 GMT and synoptic maps for two observation times (00 and 12 GMT), published by the State Institute of Hydrology and Meteorology in Warsaw, were used to analyze the barometric pressure situation on days in which foehns occurred.

In view of the fact that the above-mentioned meteorological stations have been conducting measurements in a nonuniform region, the authors had to confine themselves only to recording the frequency of occurrence of foehns. In addition, it should be mentioned that the stations in Baligrod, Komancza, Brzegi Dolne, and Ustrzyki Gorne do not record air humidity. In addition, a comparison of anemometer data from the above-mentioned six meteorological stations of the State Institute of Hydrology and Meteorology and the station in Rownia seems to indicate an improper location of anemometers at the stations in Komancza and Brzegi Dolne, since their records of wind velocities and directions differ considerably from those recorded by the remaining stations in their immediate vicinity.

The preliminary character of this study absolves the authors from analyzing the essentials and mechanism giving rise to a foehn, which incidentally has been described on many occasions in the Polish and foreign literature. We remind the readers that the problem of a foehn in the Tatra Mountains and in the West Carpathian Mountains was discussed inter alia by Bartnicki [1], Kosinska-Bartnicka [4], Milata [6,7], Michalczewski [5], Romer [10], and Orlicz [8,9]. A foehn often arises under specific pressure systems, the

consequences of which are strong barometric pressure gradients recorded between two slopes of mountain massifs or mountain ranges. Absolute elevations and relative elevation differences between the foothills of mountains and their summits also influence the formation of regional thermal and anemometric conditions.

It is well known that the West Bieszczady Mountains located within the Polish border region do not attain great heights. A characteristic feature of these mountains is their "gridlike" orography. The outline of the main ridges is regular, from NW to SE, and the hypsometric values of the ridge lines in the SE direction increase systematically. Parallel mountain ridges are separated by subsequent depressions, which are relatively wide, constituting, beside the ridges, the second dominant morphological element in this part of the Carpathians. Ravined consequent valleys are narrow, usually short, and constitute centers connecting wide and long subsequent shapes, whose bottoms rise gradually to increasingly higher elevations as one approaches the separating ridge. A fact worthwhile noting is that the width of the Carpathian Mountain Range increases suddenly east of the Oslawa valley and the Sanu valley (east of the meridional sector Rajskie-Zagorz). The regularity in the system of ridges and valley depressions mentioned above also prevails east of this line.

A disadvantage in our discussion based on observations made at the above-mentioned meteorological stations is the fact that all stations are located in valleys. Baligrod, Lesko, and Komancza are located in a meridionally oriented valley; Rownia and Brzegi Dolne are located in the subsequent valley area; and Sanok is located in a dale. Ustrzyki Gorne, the station at the highest elevation, is located on a pass between the subsequent widening and the narrow ravined consequent Wolosaty valley. The absence of a station on a peak whose records could be used has a negative influence on the entire discussion.

The average number of days in a year with a recorded foehn at the seven considered stations differs considerably. On the average, the largest number

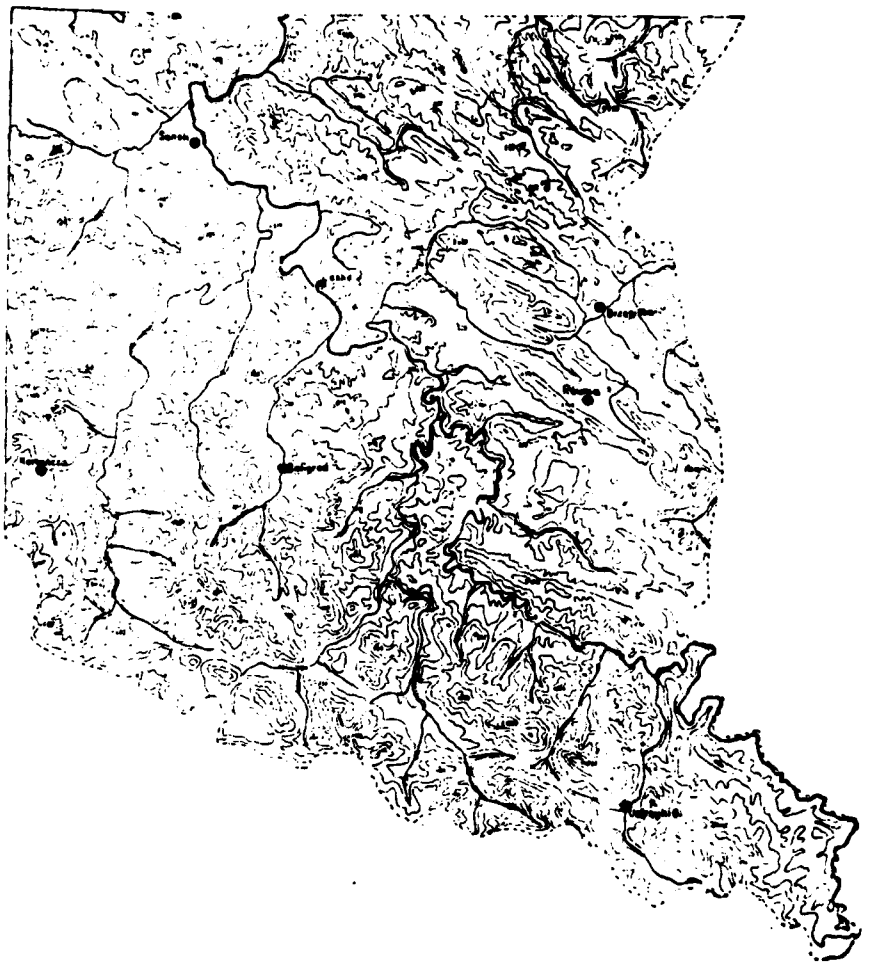

Fig. 1. Situation scheme of the terrain examined with meteorological stations

of such days was recorded at the station in Ustrzyki Gorne (14 days), and the smallest number (4 days)--at the Komancza station.

These kinds of winds occur in the West Bieszczady Mountains most frequently in the period from November to March. On the other hand, foehns did not occur in July and September during the considered period, i.e., 1961 to 1966. The number of days with a foehn in individual years and months was also different. For example, during February 1966 six days with a foehn were recorded at Ustrzyki Gorne and 19 such days were recorded during the 12 months of 1966. On the other hand, during the same month in 1961 and 1963

Table 1. The Average Number of Days with Foehns in the 1961-1966 Period

Miejscowość (a)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Rok (b)
Baligród	1.8	1,3	0,8	—	0,2	—	—	—	—	0,5	0,8	2,0	7,4
Brzegi Dolne	1.2	1,3	0,8	0,2	0,2	--	—	—	—	—	1,5	1,6	6.8
Komańcza	0,8	0,8	0,7	—	—	—	—	—	0.2	—	1,0	0,7	4.2
Lesko	2.1	1.7	1,5	0,2	0,2	—	—	—	—	0,7	1,8	1,8	10.0
Równia	0.8	2,0	2,5	0.3	0,3	0,2	—	—	0,3	0,8	1.3	2,2	10.7
Sanok	1,3	0.7	0,8	0,2	—	—	—	—	0,2	0,5	1,3	1,7	6,7
Ustrzyki Górne	2,7	2,0	3.3	0.5	0.3	0.3	—	—	0.3	1,0	1,8	2.0	14.2

* Every day in which a foehn occurred at least during one of the observation periods was assumed to be a day with a foehn.

Key: a. Location b. Year

no foehns were recorded in Ustrzyki Gorne, while they prevailed for 12 days during the 12 months of 1961 and for nine days in 1963. Four days with a foehn (total yearly number of days with a foehn equal to 18 days) was also observed in February in Rownia in the year 1965. February was not a month with an average maximum number of days with a foehn at the seven considered observation stations.

In Ustrzyki Gorne the average maximum number of days with a foehn occurred in the month of March (3.3 days), while the total number of days for this month in the 1961-1966 was 20 days. In the Rownia station the maximum average also occurred in March (2.5 days), while the total number of days for this month in the 1961-1966 period was 15 days. Secondary maxima for foehns occur usually in January or December (Ustrzyki Gorne--January average: 2.7, December average: 2.0, whereas for Rownia the January average was 0.8 and the December average was 2.2). The monthly total number of days with a foehn in Ustrzyki Gorne were 16 for January and 12 for December, and in Rownia, 5 for January and 13 for December.

With respect to the distribution of foehns throughout the year, it should be noted that the first winds already occur in September, while the last winds

still occur in June (Ustrzyki Gorne and Rownia). These two stations are most similar in this respect. On the other hand, in Komancza the months without foehns in the 1961-1966 period were April through August; in Baligrod: June through September; in Brzegi Dolne: June through October; in Sanok: May through August; and in Lesko: June through September.

The total number of days with foehns in the annual periods varied from year to year in a relatively wide range. The three locations in which this phenomenon was most pronounced during the 1961-1966 period were: Ustrzyki Gorne, Rownia, and Lesko; and the year with the smallest number of foehn winds was 1963. In that period, the yearly total number of days with a foehn was: three days in Lesko, eight days in Rownia, and nine days in Ustrzyki Gorne. On the other hand, 1965 was the year with the greatest number of days with a foehn: Lesko--17 days, Rownia--18 days, and Ustrzyki Gorne--20 days. The average yearly number of days with a foehn for the 1961-1966 period is correspondingly also smallest in Lesko (10.0 days), and increases in Rownia to 10.7 days; and the greatest yearly average number of days with a foehn occurs in Ustrzyki Gorne (14.2 days). For a comparison, we cite Orlicz [9] and Vovchenko [3]. According to the first author, on the average, 19 days with a foehn that lasted six hours or longer during a day were recorded in Zakopane. According to the second author, on the average, 10 days with a foehn wind that lasted six hours or longer during a day were recorded on the Eastern Plateau of the West Carpathians in the Ukraine.

The differences in the number of days with a foehn at least at three of the most representative stations (Ustrzyki Gorne, Rownia, and Lesko) can be explained in two ways: 1) the different location of individual observation stations relative to the main Carpathian Ridge and their distance from the dividing geomorphological bulkhead separating two different pressure systems; 2) the different topographic situation in these two locations and the different morphological relations in the immediate vicinity of the measurement points. The directions and velocities as well as the duration of a foehn in the discussed area depend not only on general circulation conditions, but also, to a considerable degree, on local relief, the elevation and direction of the

mountain ridges which are closest to the station, as well as the character of valleys, since the relief in the immediate vicinity of the station controls the lower moving air mass layers. As a result of this, stations located in valley depressions may not record and "sense" foehns with smaller velocities, especially when the latter are blowing in a direction that is perpendicular to the axis of the valley. The foehn may die out or its direction may undergo a change (turn) forced by the orography. During smaller barometric pressure gradients which prevail between the northern and southern East Carpathian Mountains, a foehn probably develops only in the immediate vicinity of the main ridge and cannot be sensed in its full force in more remote locations, even more so, since the latter are separated by several successive Bieszczady Mountain ridges running parallel to each other. There is no doubt that observation stations located on these ridges would record a considerably larger number of days with foehns throughout the year, which would also correspond to the real situation in higher atmospheric layers extending above the summit surface of the Bieszczady Mountains subjected to movement depending only on pressure differences, which are independent of the relief of the underlying surface.

Table 2. Examples of Distribution of Wind Directions and Velocities, Temperature, and Relative Air Humidity During the Foehn Wind on 21 February 1966

(a) Stacja	(b) Wiatr w m/sek.			(c) Temperatura w °C			(d) Wilgotność względna		
	7	13	21	7	13	21	7	13	21
Ustrzyki Górne	S 12	S 17	S 14	6,4	8,5	8,7	(e) brak danych		
Równia	SSE 9 (14)	SSE 8 (10)	SSE 12 (15)	8,7	11,2	10,9	64	54	58
Lesko	S 9 (12)	S 14 (20)	SSE 9 (12)	10,0	12,4	11,7	59	48	58

Remark: (14) -- gusts of wind

Key: a. Station b. Wind (in m/s) c. Temperature (in °C)
d. Relative humidity e. No data available

It is well known that during the occurrence of foehns this wind attains great velocities and that often the temperature increases sharply with a simu[illegible]neous [illegible]rease in relative air humidity. Below we present as an

example the variations and values of these elements recorded at the stations Ustrzyki Gorne, Rownia, and Lesko, during the duration of a foehn on 21 February 1966, and a table of the same elements on the sixth, seventh, and eighth of March, 1963, for Rownia.

Table 3. Examples of a Day's Course of Temperature and Relative Air Humidity and Wind Directions and Velocity During the Foehn Winds on 6, 7, and 8 March 1933, in Rownia

Godz. (a)	6 III 1963 Wiatr m sek (b)	Temperatura w °C (c)	Wilgotność względna (d)	7 III 1963 Wiatr m/sek. (b)	Temperatura w °C (c)	Wilgotność względna (d)	8 III 1963 Wiatr m/sek. (b)	Temperatura w °C (c)	Wilgotność względna (d)
1		—1,7	90		1,4	45		4,8	50
2		—1,8	90		1,5	45		4,5	50
3		—1,5	89		1,4	49		4,2	58
4		—1,5	88		1,4	49		3,9	54
5		—1,7	89		1,4	50		3,4	54
6		—2,7	87		1,6	50		3,6	58
7	C 0'0	—5,1	86	SSW 10 (15)	1,6	50	SSW 9 (12)	3,9	57
8		—2,4	88		1,8	50		4,0	57
9		—1,6	70		2,4	47		4,0	58
10		—0,7	66		3,8	45		4,2	55
11		0,0	55		4,4	40		5,2	52
12		0,0	58		4,9	40		5,8	47
13	W 1.0	1,3	54	SSW > 20,0	5,4	37	SSW 9 (13)	6,0	48
14		2,4	54		5,7	37		6,2	49
15		2,6	51		5,9	37		6,2	43
16		3,9	50		5,4	36		7,2	48
17		3.6	50		4,6	42		6,7	52
18		2.6	42		3,4	42		5,0	60
19		1.9	42		3.3	45		1,8	72
20		1,9	40		3,3	45		2,0	72
21	S 10,0	1,6	42	SSW 17 (20)	3,4	50	C 0,0	1,0	84
22		1,4	44		3.4	54		0,5	87
23		1,4	45		4,0	52		0,5	87
24		1,4	45		4.8	50		0,5	87

Key: a. Hour b. Wind (in m/s) c. Temperature (in °C)
d. Relative humidity

The situations reflected in Tables 2 and 3 depict distinctly the character and course of the phenomenon. These records document beyond any doubt the occurrence of foehns in the Bieszczady Mountains and in their foothills and supplement in this manner our knowledge about anemometric conditions in the Polish Carpathian Region.

A comparison of observations from seven meteorological stations for the 1961-1966 period shows, in addition, that pronounced regional differences were recorded in the number of days on which the occurrence of a foehn was observed in the discussed region. These differences are probably caused, as emphasized above, by the different location of measurement stations and, in addition, also by different orographic conditions in their immediate vicinity. The effect of other dynamic factors, which may also decide the greatest number of days with a foehn in Ustrzyki Gorne, also cannot be excluded. A certain basis exists for the inference that the relief in the vicinity of this station forces the winds in the northern direction. In some cases these winds can be easily mistaken for typical foehns. A clarification of this doubt and of some other points is being postponed by the authors until a more complete series of observation data is collected.

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SUMMARY

In this paper the authors present preliminary results on the föhnlike winds in the West Bieszczady Mnts. The work was based on general measurements in the years 1961—1966 at six meteorological stations of PIHM: Baligród, Brzegi Dolne, Komańcza, Lesko, Sanok, and Ustrzyki Górne, and on more accurate measurements and observations made at the station of the Department of Physical Geography, UMCS in Równia in the county of Ustrzyki Dolne. For the analysis of the barometric situation, there were used daily synoptic maps issued by the Państwowy Instytut Hydrologiczno-Meteorologiczny in Warsaw.

The average annual number of days with recorded föhnlike winds at the seven meteorological stations was very different (Table 1). The greatest number of days with föhnlike winds was recorded by the station in Ustrzyki Górne (14 days), the smallest number (only 4 days) by the station in Komańcza. Föhnlike winds in the West Bieszczady Mnts. occur most frequently from November to March. No such winds were recorded in July and August over the period of 1961—1966. The total number of days with föhnlike winds in particular years varied considerably from year to year. In Lesko only 3 days with föhnlike winds were recorded in 1963, and in 1965 — 17 days.

Considerable variations in the number of days with föhnlike winds in the West Bieszczady Mnts. can be ascribed not only to the direction and velocity of the winds in this region but also to circulatory factors and, to a high degree, to the direction of ridges and valleys which control the lower layers of the flowing air. As a result stations situated in valleys cannot record a föhnlike winds blowing perpendicularly to the valley axis. Such winds, then, die away or they change direction. It is possible that stations located on ridges would record a considerably higher number of föhnlike winds over the year.

According to Orlicz (8) the annual average number of days with föhnlike winds in Zakopane amounts to nineteen; Wowczenko reports ten days for the Carpathian foothills (Ukraine).


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